Particle Structure Fuction and Sub-barrier Fusion in Hot Nuclei*

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The existence of complex particles in a nucleus is akin to that of a solute molecule in a solvent. The effect of the solvent on a solute molecule varies from a modest modification of its properties to full dissociation. Particles (α, d, t, etc.) inside a nucleus can be seen as solutes in the nuclear solvent. Their interaction with the medium can be studied through their evaporation from compound nuclei. As a particle is segregated from a compound nucleus state and prepares to exit, it senses its environment. This environment could be a mean field, like the shell/optical model potential, or a local polarization field. This should result in states which acquire a width through their coupling with the continuum and the remaining many body degrees of freedom. A strength function should arise which modulates the spectrum of the emitted particles. This is illustrated qualitatively in Fig. 1. The states inside and above the well are the states of the particle in the nucleus, which, in the case of a proton, tend to be the shell model states well below the barrier and the optical model resonances in the continuum above the barrier.

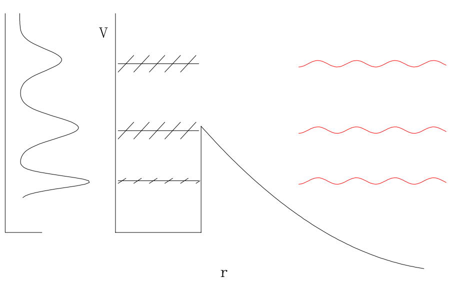

FIG. 1. Schematic drawing of the states of a particle in potential well.

The optical modulation illustrated above should be observable in very high statistics evaporation spectra. Fig. 2 provides tentative evidence for the optical modulations in α evaporation from Indium compound nuclei produced in the reaction ^{3}He+^{nat}Ag at energies ranging from 55 to 110 MeV. Shown in the lower panel of each subsection of Fig. 2 is the experimentally measured α spectrum. The upper panel of each subsection is the percentage difference between the experimental data and the fit with a spectral function which includes shape polarization:

$$P(x) \propto e^{-x/T} erfc\left(\frac{p-2x}{2\sqrt{pT}}\right), \qquad (1)$$

where $x = \varepsilon - V^0_{Coul}$. These residuals reveal a statistical significant modulation with an amplitude of about 1.5% which is repeated approximately in both amplitude and phase at all bombarding energies.

In order to extract information on the modulations observed at the various excitation energies, we have devised an analytical procedure based upon orthogonal polynomials. We write down the experimental spectrum as a linear combination of orthogonal polynomials

$$F(\varepsilon) = \sum a_n S(\varepsilon) P_n(\varepsilon), \qquad (2)$$

where $S(\varepsilon)$ is a suitably chosen weight function that generates the polynomials $P_n(\varepsilon)$. In our analysis, $S(\varepsilon)$ is chosen to be the fit with the spectral shape (Eq. 1) which represents the bulk smooth statistical background.

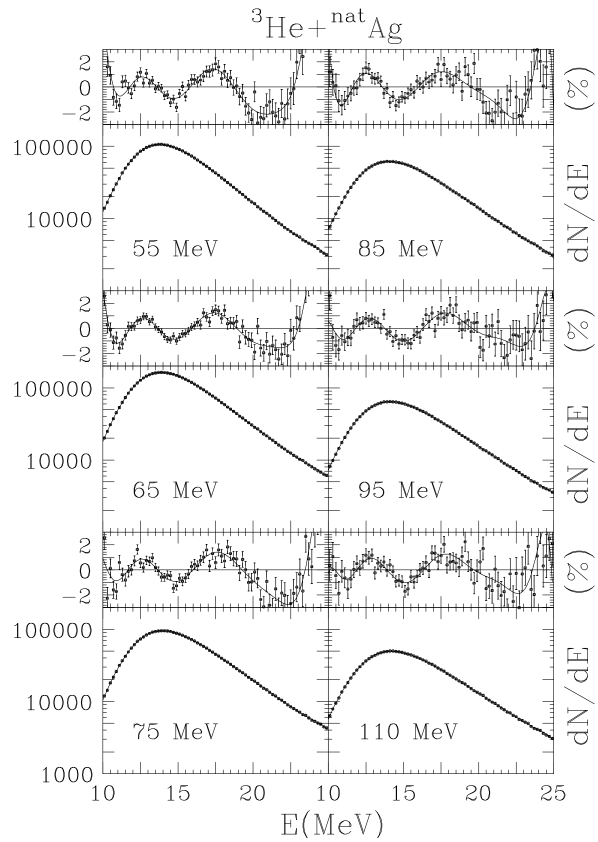

FIG. 2. Lower panels: The experimentally measured α spectra (•) and the linear combination of the orthogonal functions (Eq. 2, solid lines). Upper panels: The dots are the percentage difference between the experimental data and the fits with Eq. 1. The error bars represent the statistical errors of the experimental data. The solid lines are the percentage difference of the combination of the orthogonal functions and the fits.

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